EXD.

CONFERENCE NUMBER (Part I)

Vol. XII. Part I. March, 1939

THE

TEA QUARTERLY

IMP. INST. ENT.
— LIBRARY —
- 5 JUN 1939
SERIAL
SEPARATE
As. 94 A

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE.

PRINTERS H. W. CAVE & CO., COLOMBO

The Tea Research Institute of Ceylon.

SCIENTIFIC STAFF.

Director	...	Roland V. Norris, D.Sc. (Lond.), M.Sc. (Manc.), F.I.C.
Department of Mycology.		
Mycologist	...	C. H. Gadd, D.Sc. (Birm.)
Assistant	...	C. A. Loos.
Department of Agricultural Chemistry.		
Agricultural Chemist	...	T. Eden, D.Sc. (Manc.), A.I.C.
Research Assistant	...	J. G. Shrikhande, Ph.D. (Lond.) M.Sc. (Nagpur), A.I.C.
Assistant	...	E. N. Perera
Field Assistants	...	M. Piyasena
	...	B. T. Schuilling
Department of Biochemistry.		
Tea Technologist	...	J. Lamb, M.Sc. (Lond.) A.I.C., A.I.C.T.A.
Research Assistant		H. B. Sreerangachar, M.Sc. (Bombay), B.Sc. (Mysore), A.I.C., A.I.I.Sc.
Assistants	...	V. Mendis
	...	E. L. Keegel
	...	P. R. Perera
Department of Entomology.		
Entomologist	...	C. B. Redman King, M.A. (Cantab.), M.C.
Assistant Entomologist	...	G. D. Austin
Assistant	...	D. J. William
Field Assistant	...	W. T. Fonseka
Department of Plant Physiology.		
Plant Physiologist	...	F. R. Tubbs, Ph.D. (Lond.), D.I.C., A.R.C.S.
Assistant	...	M. H. E. Koch [F.L.S.
Field Assistants	...	F. H. Kehl
	...	F. P. Jayawardana
Small-Holdings Officers.	...	R. L. Illankoon
	...	F. D. Tillekeratne

Superintendent, St. Coombs Estate ... J. A. Rogers

NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address :—Research, Talawakelle ; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

EDITORIAL

CONFERENCE

The Sixth Conference of the Tea Research Institute was held on the 13th and 14th February and was very well attended, nearly three hundred persons being present on the first day, while on the second day one hundred and fifty visitors came to St. Coombs where special demonstrations had been arranged in each Department.

A satisfactory feature of the Conference was the greater readiness, as compared with previous occasions, of visitors to join in the discussions which were of much interest.

We were exceedingly fortunate in having with us Sir E. John Russell, F.R.S., the Director of the Rothamsted Laboratory, who opened the discussion on Soil Management and finally gave an interesting summary of his impressions at the end of the Conference. Sir John particularly stressed the importance of continuing for long periods the Institute's major field experiments, especially those concerned with manuring and cultivation, so that reliable data could be obtained based not merely on general impressions but on exact experimental evidence. The Institute has always urged the necessity for continuity in such work as it is obvious that it is only by these means that a final judgment can be reached on matters concerning which there may at present quite reasonably be differences of opinion.

Owing to the length of the Conference Proceedings it has been necessary to spread publication over two issues of *The Tea Quarterly*. The first instalment will be found in the present number.

GUEST HOUSE

A small Guest House is now available at St. Coombs where visitors can obtain accommodation and meals. The rules for the use of the Guest House will be found at the end of this issue.

ROLAND V. NORRIS.

Programme of the Sixth Conference of the Tea Research Institute of Ceylon held on February 13th & 14th, 1939.

FIRST DAY, AT THE DIMBULA ATHLETIC & CRICKET CLUB, RADELLA

Opening of the Conference by the Chairman.

"The Work of the Institute" — The Director.

Discussion on Soil Management.

(A) Sir E. John Russell, D.Sc., F.R.S. "Soil Management."

(B) Dr. T. Eden. "The Effects of Cultivation and Weeds on Tea."

"The Improvement of Planting Material" — Dr. F. R. Tubbs

Discussion on Manufacture.

(A) The Director — "Manufacturing Problems."

(B) Mr. D. W. Finley — "Heat in Relation to Manufacturing Processes."

"Disease in Non-productive Bushes" — Dr. C. H. Gadd.

"Tortrix Control" — Mr. C. B. Redman King.

SECOND DAY, AT ST. COOMBS

The Laboratories, Factory and Estate were open to visitors.

Members of the Staff explained the work in progress in their sections. There were also demonstrations or discussions as follows:

Mycological Division. —Demonstration of the diagnosis of *Phloem necrosis* and methods used in investigating its cause.

Physiological Division. —Discussion on Seed Bearers and Demonstrations of Selection and Propagation Methods.

Chemical Division. —Demonstration of Cultivation, Soil Resistance and Root Investigation Methods.

Entomological Division. —Demonstration of Pest Control Measures.

Factory. —Demonstration of Apparatus for the Rapid Determination of Moisture in Tea.

TEA RESEARCH INSTITUTE CONFERENCE

ADDRESS BY THE CHAIRMAN OF THE BOARD

MR. JAMES FORBES

Before opening the Conference, I have a very pleasant duty to perform, namely, to offer on behalf of the Tea Research Institute and all of you present today, a very warm welcome to our distinguished visitor Sir E. John Russell, F.R.S., the Director of the Rothamsted Laboratories. Sir John has specially broken his journey back to England to be present, I fear at some considerable inconvenience to himself, and I can assure him that the fact that he has shewn this interest in our proceedings in which he is himself to take part, is regarded as a great compliment by the Tea Industry of Ceylon and is most warmly appreciated by all those who are to have the privilege of listening to him today.

It is also a great pleasure to have with us some good friends of the Institute from London. I hope they will have an interesting day with us and be able to take back to London a favourable impression of the work which the Institute is endeavouring to carry out for the Industry.

This is the Sixth Conference held by the Institute, and is taking place under rather different conditions than formerly in that the proceedings of the first day are being held here in the District Club instead of in the rather cramped and uncomfortable setting of St. Coombs Factory. I feel sure visitors generally will appreciate the amenities which are at their disposal and I am most grateful to the Chairman and General Committee of the D.A.C.C. for placing the Club at our disposal and for the assistance they have given us in the arrangements for the Conference. I must also express our indebtedness to Mr. Morford, the Chairman of the Dimbula District Planters' Association and his Committee for their assistance in organising billets for some of the visitors.

I should like now to say a few words in regard to the financial affairs of the Institute.

As you are aware the question of the Institute's Cess was before the State Council at the end of last year and it is satisfactory to be

able to report that the request of the Board, which received overwhelming support from the Industry as a whole, that the cess should be continued at 14 cents per 100 lb. of tea exported for a further period of five years expiring at 31st December, 1943, was passed without opposition. Our income for the next five years, if no major external disturbances arise, may be considered as reasonably assured and the research programme can, therefore, we hope, be developed on a systematic and progressive basis.

This programme must, however, remain based on our present resources in regard to staff and equipment, since we feel that we cannot at present safely incur further liabilities which may lead to any material increase in our recurring expenditure. Such expenditure has naturally risen considerably since the Institute was first started but I do not think the Industry as a whole has any complaint to make on that score. On the contrary it may reasonably be claimed that the Industry is receiving a good return for its outlay. It was naturally not possible when the scheme for the Institute was first drawn up to envisage with exactitude what calls would be made upon us by the Industry. Quite early however, it was apparent that work on pruning, with special reference to low-country conditions, was urgently required, the result being the addition of the Plant Physiologist's Department. Following on this a demand quickly arose for work at outstations in regard to special problems of local interest. This led to the setting up of our Sub-Station at Passara, and the institution of experiments on various subjects in other areas. At the same time it was necessary to consider the requirements of small-holders who of course are also contributors to the scheme, and this has necessitated the appointment of two full-time advisory officers to assist small-holders. All these developments which, I think, you will agree were inevitable and in the interests of the Industry, have naturally led to a higher recurring expenditure. The Board has, however, recently carefully reviewed the position and is satisfied that its policy in these matters has been correct and I have little doubt, gentlemen, that you will support that conclusion.

In the remarks which the Director will shortly have to make to you there are several issues to be raised regarding which I hope we shall receive the benefit of your suggestions and criticisms.

As he will tell you, there has been a rapidly increasing demand for the services of the Institute's staff; in the last year alone enquiries have increased by nearly 25 per cent over the previous year This is of course highly satisfactory since it is a most conclusive proof that both Proprietors and Superintendents in immediate charge of estates are finding that the Institute can be of real assistance to them. But the success of this side of the Institute's work has also

its embarrassing side. The advisory work is naturally based on the laboratory and field investigations of the staff and the Director tells me the time is rapidly approaching when some adjustment will become necessary in order that the time available for the latter fundamental work may not be unduly restricted.

There is further the question of maintaining and increasing the personal contacts between the Staff and the Planter. Everyone will agree as to the importance of this, but the means of giving effect to such a policy are not altogether easy, taking into consideration the limitation imposed by the conditions to which I have just referred.

In conclusion, gentlemen, I have to reiterate a request which every Chairman of such a conference as this has inevitably to make. That is, as you will have anticipated, to ask as many of you as time will allow to join in the discussions we are to have today. I know that the Director and Staff have been somewhat disappointed with this aspect of previous conferences. Many of you have applied to the Institute for advice on various aspects of your work. The conference offers you an opportunity to indicate, how far that advice has proved sound. It is obviously of help to the staff to know what has been the practical results of their recommendations and I hope that really useful discussions will follow. I can only add that should any of you be overcome by that excessive diffidence which so often seems to attack members of a gathering such as this, there are resources readily available which may serve to provide a not unpleasant and effective remedy.

THE WORK OF THE TEA RESEARCH INSTITUTE

ROLAND V. NORRIS, D.Sc., F.I.C.,
DIRECTOR

I should first of all like to associate myself and the Scientific Staff of the Institute with the welcome which has been accorded to Sir John Russell. Though Sir John is not a stranger to Ceylon this is the first occasion on which it has been possible for him to visit the Institute and we greatly value the opportunity this has afforded for us to discuss certain aspects of our work with him.

At previous conferences it has been usual for me briefly to review some of the technical aspects of our work. Today, however, I intend to deal more particularly with the general policy underlying that work. I shall then pass on to discuss the methods by which

the information acquired by the Institute can best be passed on to the Planter and turned to practical effect.

As the Chairman has told you this morning, the scope of our activities is controlled not by the number of problems which call for attention but by the financial resources at our disposal, which necessarily limit the numbers of technical officers the Institute can maintain. It is not perhaps always realised that the staff of the Tea Research Institute is considerably smaller than that of the corresponding Institutes in Assam and the Netherlands East Indies. There is no prospect, however, of any increase in staff during the next few years. Our present commitments are such that no material increase in our recurring expenditure can be contemplated.

It is clear therefore that our future programme of work must be based on our present resources and, in view of these limitations, it is obvious that the greatest care must be taken in framing that programme in order that attention may be focussed on problems which are really of major and general interest. Otherwise there is a very real risk of the work being spread over too wide a field, leading to a relatively superficial treatment of a large number of problems, which would, I think, be of less benefit to the Industry than intensive study in a more limited range. This consideration has from the beginning governed our experimental policy.

An experimental programme once laid down must, so far as possible, be adhered to and proceed without interruption. This unfortunately is rather a counsel of perfection. It is inevitable that from time to time problems suddenly arise, may be the outbreak of disease, the appearance of a pest, some controversial aspect of cultivation, some particular market requirement in relation to manufacture, which demand immediate *ad hoc* attention to the interruption of regular work. But such interruptions should be resisted so far as possible and it is not to the benefit of the Industry that attempts should from time to time be made to stampede the Institute into work on this or that problem which may perhaps really be of ephemeral interest only and the importance of which to the Industry as a whole may easily be exaggerated.

Assuming the above limitations to be necessary, it is of importance, however, that the Institute should be well informed as to the requirements and particular problems of the various tea districts in order that a proper balance may be maintained. Otherwise there will inevitably be complaints of discrimination. This difficulty is to some extent met by the composition of our Experimental Sub-Committee which as you are aware contains a number of practising planters from different districts of the Island.

A conference such as the present, however, at which all districts are well represented affords naturally a much better opportunity for suggestions, comments and, if necessary, criticism to be made regarding the lines on which the Institute is working. I do ask you to avail yourselves of this opportunity. Otherwise you can hardly blame us if we assume that our programme and policy has your full endorsement and is considered generally suitable to the requirements of the Industry.

To enable you to make such comment I must, however, indicate to you shortly and in general terms what are the major lines of work which will be occupying our attention in the immediate future.

DISEASES AND PESTS

Dealing first with the question of diseases and pests, the work of the officers concerned with these subjects comes under two heads. There is first of all general advisory work, to some extent of a routine nature, in regard to enquiries about the better known diseases and pests and their control. But unfortunately there are other diseases of which the origin and method of transmission are obscure, other pests for which adequate methods of control are not yet available, and research is of course actively proceeding on such problems. In certain cases considerable progress has been made, in others the solution is not yet apparent. In regard to Tortrix, for example, as you will hear from Mr. King this afternoon, the results are now so promising that you will be asked to consider the desirability of some relaxation in the regulations under the Plant Pest Ordinance dealing with this pest.

With Shot-hole borer, however, the question of control is still unsolved and the pest seems gradually to be spreading to higher elevations. It must be remembered that in the case of a crop like tea many of the methods normally used for the control of insect pests are impracticable since one cannot for obvious reasons use poisonous sprays for mature tea. One is therefore more and more driven to look for methods of biological control. We have been in touch with the Farnham Royal Laboratory in England, with India, and also with the United States in an effort to obtain some predators or parasite which may serve to control Shot-hole borer. The Farnham Royal Laboratory were kind enough to collect a consignment of certain species which were considered worth a trial. Unfortunately the vagaries of the air mail at this time led to such delay in the arrival of the parasites that very few of them had survived the journey. Quite frankly, as at present advised, I am not very hopeful of any immediate success. We shall, however, continue this work until we are satisfied that some other avenue of approach offers better prospects.

With the disease known as *Phloem necrosis*, the cause still remains quite obscure. Research on this is actively proceeding in the Mycological Department and Dr. Gadd will address you on the subject this afternoon. I will not anticipate his remarks further than to say that we have every reason to think that the distribution of the disease is much wider than was at first thought to be the case and one of our objects in bringing up the question today is to obtain further information on this point.

Before passing on to agricultural matters I must make a reference to eelworm. The Institute felt it necessary to issue a warning regarding the increase of this pest as the result of the *continuous* growth in the tea of susceptible species of green manures. There has, I think, been some misunderstanding regarding this warning which has led in some quarters to the total abandonment of some very useful species of green manures on the grounds of their liability to eelworm attack. What actually was suggested by the Institute was that no one species of green manure should be grown continuously but a *rotation* employed. Non-susceptible species would of course be included in the rotation. Such a practice would by leaving periods during which eelworm would find nothing on which to maintain itself definitely limit the multiplication of this pest.

AGRICULTURAL RESEARCH

Manurial experiments have until recently been the chief function of the Agricultural Section and no one here will, I think, deny that these have been of the greatest practical benefit to the Industry and that very large savings indeed have resulted from the wide adoption of the Institute's recommendations on this subject. These experiments deal not only with the type and quantity of manure applied, but have recently been extended to deal with the time of application. As a result the Institute has, as you know, suggested that, speaking generally, it is advantageous to defer for a few months the application formerly usually given at the time of pruning. There are some who are not in agreement with this recommendation and I hope they will have something to say on the question today.

The manurial experiments are to continue of course, but considerable attention is now being given to the question of cultivation and its relationship to root distribution, weeding, cover crops and soil conservation. Dr. Eden will deal with certain aspects of these questions this morning and there should be scope for ample discussion on some of the issues to be raised.

PHYSIOLOGICAL

The work of the Physiological Section which for the first six or seven years was chiefly concerned, and I think I may say very successfully concerned, with pruning problems will in the immediate

future be concentrated almost entirely on tea selection and propagation. I think few will dispute the necessity for such work to be developed as rapidly as possible. It is a matter of common experience that our tea fields contain large numbers of uneconomic bushes while there are undoubtedly large variations in quality between the numerous types of bushes found. If we are to hold our own in competition with other producing countries, we shall have to take steps to ensure that our future yields shall be higher and quality at least maintained — I hope improved. This demands that future replanting, and there is ample scope for this, shall be carried out with selected material. The results obtained in other countries and the work so far carried out at St. Coombs indicate that there should be little difficulty in increasing yields and probably less difficulty than we at first anticipated in combining these with improved quality.

It may seem in these days of restriction, somewhat perverse to talk of increased yields. I suggest, however, that there are in Ceylon considerable areas of tea land, steep soil-eroded areas for example, which are of very doubtful economic value. If replanting on a large scale is to be carried out in the future it may well be that some of these areas will be abandoned and that, if production of tea on a larger scale is still not required, it will be found advantageous to rely on smaller areas planted up with higher yielding strains and therefore more economically worked. We are, I think, too much inclined to concentrate on high selling prices without considering the equal importance of lower costs of production It may be more easy to achieve the latter than the former.

TEA MANUFACTURE AND BIOCHEMICAL WORK

I do not propose to say much concerning work on these subjects at the present moment as a part of this afternoon's programme is allocated to a discussion on manufacture and it will be more convenient to deal with this aspect of our work then. I will only say now that after long delays it has proved feasible to arrange for the financing by India, the Netherlands East Indies and Ceylon of joint research to be carried out in Europe on the Chemistry of tea. The scheme is to provide in the first place for a five-year programme of research for which it is expected a sum of about £1,000 per annum will be available. Should this work, as I hope and believe it will, prove productive, we may hope to have available information by which those working on the practical aspects of manufacture will be enabled to follow the various changes which take place during manufacture in a much more precise and quantitative basis than is at present possible.

ADVISORY WORK

I must pass on now to another aspect of the Institute's work regarding which I think neither the extent nor the importance is adequately recognised. — I refer to our general advisory work.

When the Institute was first started I imagine there were a good many people who perhaps thought that progress would be signalised by a series of rather revolutionary recommendations announced at fairly frequent and regular intervals in our publications. Unfortunately it is rarely, particularly in agricultural research, that the actual facts are so spectacular. That our publications are valued and appreciated, however, is evidenced by the wide demand for these, not only in Ceylon but in other tea-producing countries where we have a large number of subscribers. The articles in *The Tea Quarterly* and Bulletins must, however, be expressed in somewhat general terms and the broad principles formulated there must necessarily be adapted and modified to some extent in their application to individual estates. This is of course effected by means of correspondence, visits to estates by members of the staff, and visits by planters to the Institute. I have no hesitation in saying that the advisory work carried out in this way has in the past few years considerably modified estate practice in every branch of work. The proof of the success of this work is the rapid increase in the number of enquiries received and in the demand for estate visits. In the past year alone such enquiries increased by at least 25 per cent. and 185 visits were paid to estates by members of the staff and the latter number would have even been greater if time could have been spared. About 180 visitors came up to St. Coombs. This is of course highly satisfactory but has its embarrassing side.

Quite apart from the advisory work carried out by correspondence only, the above estate visits, lectures to District Planters' Associations or other similar organisations, and the Director's touring consumed time equivalent to the whole working year of one officer, Sundays excluded. Nor is that the whole story: a visit to an estate normally involves the writing of a report, the giving of a lecture, the preparation and writing of an address. The total time involved in the advisory work is, therefore, much greater than the figure just quoted. Work in connection with small-holdings is not included in the above calculation since we have two assistants who devote their whole time to small-holdings.

I have stressed the above facts because it is through this work that the information gained by Research Officers is really brought to the personal knowledge of the Planter, Visiting Agent or Proprietor, and largely by this means that planting practice is gradually being influenced.

But with our present resources there must naturally be some limitation to the time that can be given to this part of the work. Otherwise inadequate time will remain for experimental work on which it will be realised the advisory work must be based. I am exceedingly loath to refuse any request for a visit to be made to an estate since I appreciate most fully the value of the personal contacts thus established. During the past year, however, I have had to make such refusals for the reasons indicated and in the present year no doubt the same will occur. I hope the explanations I have given will mitigate the annoyance of anyone who may suffer in this way.

The practical issue is, how can the position be remedied? The first observation I would make is that experience has shown that a certain number of the problems concerning which visits have been requested and made could have been satisfactorily dealt with either by the sending of specimens or fuller records to St. Coombs or by the visit of the Superintendent to St. Coombs. I would like to see a much larger number of visitors to the Institute. Apart from the fact that this will to some extent ease the strain in regard to visiting by the staff, it has the further advantage that a visitor coming to the Institute for some specific enquiry can take the opportunity at the same time to meet other members of the staff and learn something of other aspects of the Institute's work. Possibly some of you, particularly those whose estates are at a distance from St. Coombs, are now thinking — what about the expense incurred on such visits? Well, gentlemen, all I can say about that is that if, as presumably will be the case, you are coming to St. Coombs in the interests of your Company it seems reasonable that some allowance should be made on estate account towards the cost of that visit.

In regard to such visits I must, however, make one comment. I find from our records for last year that not more than 25 per cent of our visitors came to St. Coombs on Visitors' Days. One wishes to place as few obstacles in the way of intending visitors as possible, but visits concentrated on certain days cause much less interruption to officers' work than when they are scattered over many days in the month. The situation might perhaps be eased by having two official visiting days each month instead of one. A prospective visitor might not wish to postpone the discussion he desires to have for possibly nearly a month. If that interval were halved there should be less difficulty in more strictly limiting visits to specific days. I should be glad of your comments on this question.

I should add in regard to visits to St. Coombs that further facilities are now available. A small Guest House has just been

completed where visitors can obtain accommodation and refreshment and I hope this will prove a real convenience to those coming from a distance.

I wish to refer now to another suggestion which has been tentatively made from time to time, namely that the Institute should hold short instructional courses for planters. The main advantage to be gained is that an opportunity would be afforded to some of the younger men to establish contact with the Institute. It would perhaps be feasible to arrange such courses, but from what I have said you will appreciate that they would have to be very definitely limited in scope, that is to say, both as regards numbers and time.

I think it is well this should be clearly understood. The Institute is not an Agricultural College and any instructional work undertaken should be regarded as quite subsidiary to the Institute's research functions.

I referred earlier to the importance of seeing that all districts are kept informed of the work in progress. This is to some extent achieved by means of lectures. It might, however, be of assistance if periodically meetings were held at St.Coombs between the Scientific Staff and representatives nominated by the various District Planting Associations. Such representatives could keep the staff in touch with local problems and also convey to members of their Associations a more accurate impression of what is going on at St. Coombs than is perhaps gained from casual conversation round the club bar. I should be glad to hear from you whether you consider such meetings would be helpful.

Finally, there is the question of our conferences. As the Chairman has told you we have been rather disappointed on former occasions by the lack of real *discussion*. I should welcome any suggestions you may care to make in regard to the way these conferences should be organised. I should also be glad to know whether in your opinion it would be advantageous, quite apart from the main conferences, to hold at irregular intervals as required small conferences to discuss any special problem of immediate topical interest.

I have addressed you today in rather general terms but the issues raised are, I think, of importance in so far as the organisation of the Institute's work is concerned. I invite your co-operation in our efforts to make this organisation as efficient and useful as possible.

DISCUSSION

Mr. I. L. Cameron said he understood that at Tocklai and the Rubber Research Institute of Malaya the staff included Field Officers and wished to know whether this arrangement had proved successful in regard to visits to estates.

The Director said he presumed Mr. Cameron was referring to special officers for advisory work. He did not think such staff existed at the Rubber Research Institute of Malaya but at Tocklai four officers had recently been appointed for advisory duties. These officers were now undergoing further training, on the completion of which they would be appointed to outstations where they would supervise experimental work in these areas and act generally as advisory officers for their districts. They had not yet, however, assumed such duties.

Mr. Boileau asked when a really comprehensive index to the Tea Research Institute's publications would be available, and pointed out that with the large mass of material which had now accumulated it was very difficult to track down information on a particular subject without a combined index.

The Director said he must apologise for the fact that a general index had not already appeared. He had hoped to issue this in the previous year but had been handicapped by the absence of officers on leave. He would assure Mr. Boileau that the index would be published later in the present year.

Mr. P. A. Keiller said he had thought a good deal about the difficult question of discussions at the conference. He suggested that in future the papers should be issued in full before the conference, the whole time of the meeting being thus left available for discussion. Otherwise the utility of the discussions would be reduced owing to the lack of time available.

With regard to the Director's other suggestions, he thought the proposal that the Scientific Staff should have occasional meetings with representatives nominated by District Planters' Associations was a good one and likely to be better than holding small conferences. The difficulty in regard to the latter would be to restrict their size; it would be impossible to tell in advance whether the conference would be a small or large one. He suggested that districts might nominate two representatives each for such meetings but not necessarily the same men on each occasion. The choice of persons would depend on the particular problems which it was considered desirable should be discussed. In this way the local problems of each district

would be adequately presented. He thought two representatives were necessary as districts would then probably receive a fuller and more accurate account of the discussions.

With regard to instructional courses he was inclined to agree with the view that the functions of the Institute were not those of an Agricultural College. He doubted personally whether such courses would be of very great use as they would necessarily have to be very restricted in scope.

The Director in reply to Mr. Keiller said there would be many advantages if the time of the conferences could be utilised mainly for discussions. The full papers to be discussed would of course have to be issued in advance and success would depend entirely on whether those attending the conference were prepared to study these papers thoroughly in advance. Provided that happened better discussions would undoubtedly result.

In regard to instructional courses, Dr. Norris said he did not wish to be misunderstood as to his attitude. There were certain obvious advantages to be gained from such courses in that the younger planters who might attend would thus come in closer contact with the work of the Institute and be in a better position to understand the general principles involved. This would have useful repercussions in the future. Instructional courses, if held, would no doubt be on similar lines to those given at Tocklai. There two courses were given per annum, each lasting one week. The mornings were devoted to lectures by the staff covering the general activities of the Institute, while in the afternoon the class was divided up into groups, the latter spending one afternoon in each department.

He did not, for the reasons given earlier, consider that St. Coombs could do more than this, and it must not for a moment be imagined that a man who had attended such a course was to be regarded as possessing special qualifications in the scientific sense or that certificates would be issued suggesting that such were the case.

Mr. Wilfred Rettie said that while the Institute's present conferences were invaluable in disseminating information and ventilating opinion, he thought it would be of great advantage if the Institute's staff could from time to time hold small round table conferences with some of the leading agricultural experts of the Island. There were certain subjects which might be regarded as controversial, or regarding which there was at any rate a considerable difference of opinion, and it would eliminate much confusion if such matters could be thoroughly discussed at small conferences of experts such as he now suggested.

Mr. Kenneth Morford said that one difficulty which occasionally arose was that there was a tendency for a recommendation made at the conference to be adopted on an island-wide basis, irrespective of whether the particular discussion had really referred to low, mid or up-country conditions. As examples he referred to the question of rim-lung pruning which was really recommended for the low-country but had been adopted quite widely up-country, and the warning issued in regard to the association of certain green manures and eelworm which had been given a much more drastic interpretation that was really intended by the Institute. He therefore supported Mr. Keiller's suggestion in regard to the holding of discussions between the Scientific Staff and district representatives since he thought districts in this way would obtain a clearer indication of the scope of the recommendations made by the Institute.

Mr. Hubert Tonks said that in regard to estate visiting by the Scientific Staff he wished to make the suggestion that when an officer was asked to visit a particular estate to discuss some subject which was perhaps of general local interest, other Superintendents in the neighbourhood might at the Director's discretion be asked to be present at the same time. He thought this might perhaps lead to some reduction in the number of estate visits required and give some relief in a matter which was now embarrassing the Senior Staff.

Mr. R. C. Scott said that Mr. Keiller's suggestion was one which appealed to him very much and he hoped it would receive wide support. He recalled that after the Rubber Conference organised by Mr. Farquharson last November, it had been decided to appoint what would probably be a Standing Committee to keep in touch with problems as they arose; he was delighted to note that the present meeting appeared to favour the appointment of a somewhat similar Committee. He thought the details of the necessary arrangements could be left to the Chairman and his Board who could decide as to what action could advantageously be taken.

SOIL MANAGEMENT

SIR JOHN RUSSELL, D. Sc., F. R. S.

DIRECTOR OF THE ROTHAMSTED EXPERIMENTAL STATION

Two general policies have been adopted in regard to the management of the soil. Before the war many of those who went out from the older to the newer countries were aiming frankly at soil exploitation. "Get what you can while you can" was the motto, and while the policy brought in money to some of the pioneers, it has in many places ended disastrously. The other method was to aim at permanent productiveness; to study carefully the fertility of the soil and do nothing which would tend to destroy it. This was the policy of the older English agriculturists, and it goes back to the old feudal times when the land was regarded as the one permanent asset, and the family as the permanent possessor. Modern experience shows that permanent fertility is possible, and that a sound system of management will enable the earth to yield its increase perpetually. The top soil can go on being productive indefinitely, unlike the mine which, once used up, is exhausted for ever.

There are several essential conditions for permanent fertility. First of all the soil must remain where it is. Of course it may be levelled or terraced but speaking generally it must remain in position. The idea seems obvious enough to an Englishman coming out fresh from experience with British agriculture, but it would have been recognised as very important by the old Roman agriculturists who were painfully familiar with the problem of soil erosion. Three thousand years ago the Mediterranean regions were forested; then as mankind pushed westwards the forests were cleared leaving a fertile soil; then soil erosion began leaving the land bare and unproductive. Much of it remains so to this day. Meanwhile progressive agriculturists pushed northwards and north-westwards into regions where soil erosion does not usually occur and so the matter was forgotten. It was not till North America was opened up in the 19th century that soil erosion came up once more as a problem, and then it quickly spread and appeared in Africa, India, here in Ceylon and elsewhere.

The whole trouble had arisen from the removal of the natural cover of vegetation and the substitution of a new cover which was nothing like so effective for preserving the soil; in consequence the soil was lost. The reason why soil erosion is not a problem in England

is that natural vegetation springs up very rapidly on uncultivated land and the rain is not intense enough to wash away the soil during the short time that it remains bare. Indeed, the trouble is generally the other way about, and the English farmer is often rather worried by the rapid growth of the vegetative cover and has had to evolve methods of cultivation to eliminate these weeds, as he calls them. The weed problem of the English farmer is thus the counterpart of the erosion problem in other parts of the world; if you don't get one you are liable to get the other.

It is not necessary for me to elaborate this question of soil erosion as you are all familiar with Dr. Eden's valuable summary of the subject issued by the Imperial Bureau of Soil Science in 1933. Ceylon was one of the pioneer countries in recognising the trouble and as far back as 1873 Hooker had drawn attention to the evil results of indiscriminately clearing the forest, which was beginning to cause denudation. The Forest Ordinance of 1885, and the Kelani Valley Railway Commission of 1894 were further stages. But the most important step in Ceylon was the setting up in 1929 of the Government Committee on Soil Erosion which in 1931 issued its Report, now one of the classics of the subject. There are two essential steps for preventing soil erosion. The first is the growing of some crop that will cover the ground and protect the soil against the mechanical beating power of the rain; also the roots of the covering crop help the formation of soil crumbs which are stable to water and therefore resist erosion more than the separate particles would do. Further, the covering vegetation as it dies supplies organic matter to the soil, and this is one of the most important elements in making its fertility. The second essential requisite is the prevention of run-off of rain water; the rain water must be made to soak in, instead of being allowed to run off. Drainage must of course be arranged. The up-and-down planting of bushes so popular with the older planters has to be replaced by a contour planting and where necessary and practicable contour banks are arranged. Elsewhere terraces, bunds, or in bad cases of gully erosion even dams, are erected in regions where land is limited in area and therefore very valuable, as in Japan.

The first essential in soil management is to take the proper steps to prevent soil erosion. It is often difficult to do this in practice because many different bodies may be concerned, and it may be hard to bring them together and harder still to get them to act quickly. But without prompt action when erosion first begins the trouble may go to great lengths and cause very serious losses.

Another important item in soil management is to ensure a full supply of plant food in the soil. The crop takes out nitrogen, phos-

phate, potash and other elements. The older British agriculturists were very afraid of this process, fearing that the constant cropping would exhaust the soil of plant food and so leave it sterile, and unable to carry any more crops. There was never enough farmyard manure to give to all the land, and a variety of other substances, bones, etc., were used in the old days. The introduction of artificial fertilizers nearly 100 years ago as the result of the Rothamsted experiments overcame this difficulty entirely, and the working out of new methods of field experiment by Fisher and Yates on the statistical side, and Dr. Eden and others on the field side; has shown how the fertilizer requirements of crops can be discovered. Dr. Eden has shown the marked need of the tea plant for readily available nitrogen such as sulphate of ammonia, blood meal and ground nut cake, a less pronounced response to phosphate, and still less to potash. When potash is in question the form in which it is supplied is often raised. Our results show that sulphate of potash is slightly superior to muriate on a quality crop like potatoes in production of both yield and quality, but the difference is associated with low rainfall and is not likely to affect tea under Ceylon conditions. Indefinitely large supplies of all these substances are available and one need have not the slightest fear that soil exhaustion will ever arise. The manurial problems that now require investigation are those connected with the proper time of applying the fertilizer, the most economical quantities to use, and their effect on the growth of the plant, its reaction to weather conditions and to the attacks of insect and fungus pests, and on the quality of the tea finally produced

There has been a great deal of discussion as to whether organic manures such as blood, hoof and bone meal, poultry manure, etc. are or are not better than the ordinary artificial fertilizers. They are probably more fool-proof but they are rarely quite as effective as the other fertilizers and usually much more costly per unit of plant food supplied and of crop increase obtained. I have come across a few cases where organic manure seemed to have some special action; in our experiments with Brussels sprouts we occasionally found poultry manure better than artificial fertilizers, though usually it was the other way about. Salesmen sometimes maintain that fruit grown with artificial fertilizers is inferior in taste and quality to that grown with organic manure. The same claim has been made for other products. I know of no definite evidence in favour of this claim, and I am inclined to think the salesman must have been handling some samples where artificial manures had been wrongly used. So far as tea is concerned the problem is, however, one for experimental enquiry. What usually happens in our experiments with barley, potatoes and other crops is that potash tends to improve the quality, though not always very much, and nitrogen

has no effect one way or the other so long as it is used in quantities that steadily increase the crop, but in larger quantities, where the crop increase falls off, the quality may suffer. For English conditions the limit is often 20 or 30 lb. of nitrogen per acre. For tea it might easily be higher.

Farmyard manure is in a special position as it does things to the soil that artificial fertilizers do not. It breaks down to produce humus in the soil, and in the process it supplies the plant with nitrogen. But it is not an economical supplier of nitrogen to the crop. In our experiments at Rothamsted it took about 3 to 5 parts of farmyard manure nitrogen to produce the same effect as one part of nitrogen in sulphate of ammonia. It has many virtues and one would like to use more of it, but unfortunately it is never available in sufficient quantity.

This has led to methods for ekeing out the supplies of farmyard manure and for finding substitutes. One of the oldest of these is the making of composts. The art is very ancient, and composts were well known to the old Arab agriculturists, and they are described by one of their writers, Ibu al Awar, in the 10th or 12th century. Composts were in the old days used in England when labour was cheap and abundant, and composting by the Adco process is today used in England in gardens and by some market gardens, but not usually on farms because the cost is too high. Indeed it is this high cost that prevents the process being more used; there is no evidence that the manurial value per ton is sufficient to justify much expenditure. Composts are of course very variable both in composition and in action, and they may range from a rich and effective mixture of human and animal excrements with vegetable wastes, down to a poor mixture of old vegetation of little value in the soil. There is no particular virtue in composting, and you get no more out of the heap than you put into it, indeed rather less, as there is always some loss. It is largely a matter of cost, convenience and carbon-nitrogen ratio whether you dig the vegetable material straight into the soil, or make it into compost and dig that in. But the nitrogen is not nearly so effective as that of sulphate of ammonia.

Compost certainly helps to form humus in the soil and this is frequently an advantage, but forking vegetable matter straight in does the same. The problem is essentially one for experiment; it is a question of fact and not of opinion, and if careful costing shows that the price of the material is too high, it obviously cannot be used in a commercial enterprise.

Green manuring is usually a cheaper and more effective way of putting organic matter into the soil, and you are fortunate here in having green manure crops like the dadap and certain weeds that,

if left, act as soil protectors while they are living and as manure when they are dead. This method of selective weeding seems to me to be of considerable importance and one with a good deal of future possibility. A good leguminous green manure is one of the cheapest and most effective ways of adding nitrogen to the soil, and in addition the root action seems to have a special value in forming soil crumbs and so increasing the stability of the soil.

You are fortunate in escaping one of the most serious difficulties of the British farmer — loss of lime from the soil. Just as weeds and erosion are the two counterparts of the soil conservation problem so lime and soil acidity are counterparts of the soil reaction problem. It does not exist for you and so we need not discuss it.

There is another problem, however, which you may not escape so easily. The classical elements of soil fertility, nitrogen, potassium, calcium, magnesium, etc., are now known to be inadequate for complete nutrition of the plant; certain other elements, sulphur, iron, manganese, boron, zinc, copper and perhaps others are required also, though in very small amounts. Their absence is shown by a loss of vigour of the plant, and in extreme cases by the setting in of some definite disease. For some of these elements the deficiency symptoms are now known: deficiency of sulphur caused a yellowing of tea in Nyasaland; deficiency of copper causes the shoots of various trees to die back and deficiency of zinc causes rosetting of various deciduous trees. It is possible that the occasional instances where organic manures produce better effects than artificials may be attributable, in part at any rate, to the supply of these minor elements. The problem is one to be carefully watched.

I have left to the last the question of cultivation, one of the most important items in soil management. Present practices are largely based on the old English and Scottish gardening technique where a good seed bed had to be obtained and where weeds had to be kept down because they competed with the crop, and because they offended the master's sense of neatness. There was no fear of soil erosion or of other losses, and so long as labour was cheap, abundant, and good, the gardens and the show farms were models of clean weeding and tidiness. But it is all so different now, and these standards do not necessarily hold. It is a matter entirely for experiment to determine how far cultivation should go. In our experiments at Rothamsted we have found that cultivation beyond what is necessary for getting a seed bed and keeping down weeds is unnecessary; at best it is a waste of money and may even reduce the crop by damaging the plant roots. We showed this for sugar-beet, kale and other crops. Fortunately Dr. Eden has been experimenting on this subject and will tell us of his results. Here again

it is a question of fact and not of opinion. There arose an idea in the 19th century that cultivation improves the water supply for the plant. This is so, up to a point. You can reduce the run-off and waste of water by cultivation and so improve the soil reserves of moisture, and you can reduce the temperature of soil directly exposed to the sun by loosening the top layer. But the old idea that you must constantly cultivate in order to break up capillary tubes and so stop upward capillary movement of water has had to be given up; it was pretty and attractive, but had little relation to the facts. Our present idea of cultivation is that it serves three purposes:—

(1) It gives the young plant a good start, and we all know how important that is.

(2). It keeps a proper balance between the crop that you have planted and the wild vegetation that plants itself.

(3) It helps in regulating root development, which in turn determines the volume of soil through which the roots can range in search of moisture and food.

But against this, cultivation may damage the roots, and if it is carried out beyond a certain amount it is at best a waste of money and it may even do harm.

All this shows the need for constant experiment to get at the facts and to express them in such a way that the planter can use them. As the economic conditions change and market demands alter, so the problems change, and as long as the tea-growing industry continues so long will it be necessary to maintain a Tea Research Institute with a highly competent staff to deal with these ever-changing problems as they arise. The greater the efficiency of the planters the higher must be the standard of the research workers. You in Ceylon are particularly fortunate both in your tea planters and in your Tea Research Institute. Let us hope this will always be so; it is certainly the best means of assuring the continued efficiency of the Industry on which the prosperity of Ceylon so greatly depends.

DISCUSSION

Mr. I. L. Cameron remarked on Sir John's reference to cultivation as a preventative of run-off and asked if that was applicable to steep slopes such as those met with in Ceylon. He would also like to know whether the broadcasting of inorganic fertilizers without forking or burying would enable fertilizers to penetrate to a sufficient depth.

Sir John Russell replied that as regards run-off, he thought cultivation was necessary in order to loosen soil sufficiently to allow the rain to soak through. Some sort of drainage would have to be arranged, and the proper type would be determined by observation and trial. Continuing, he said that the question of how best to get artificial fertilizers into the soil was always a problem. Without dogmatizing about tea, he could say that in the Rothamsted experiments they found that the best results accrued when the manures were well incorporated in the soil. Top dressings of soluble fertilizers could be used because they washed down into the soil to some extent. He thought that the manuring programme would have to be related to the programme of general management and cultivation and this included the question of efficient working in of fertilizers.

Mr. S. F. H. Perera said that formerly plant foods were obtained from organic sources, but that the modern tendency was to use mineral manures. He wished to know whether the continuous use of these mineral manures destroyed the tilth and physical condition of the soil.

Sir John Russell replied that on that point their evidence at Rothamsted was of value because it had been a matter of experiment over a longer period than that during which tea had been grown in Ceylon. They had plots which had received quantities up to 800 and 900 lb. per acre of mineral manures every year since 1843, and there was no sign of destruction of tilth. But one could not expect to keep up soil fertility exclusively on mineral fertilizers. They should be used with green manures. He could not recommend a programme of exclusively inorganic manuring but stipulated that organic matter of some kind should be forked in as well.

Mr. M. L. Wilkins asked whether exposure to the sun had any effect on soil. He referred to the recent mania for composting prunings, a practice which left pruned areas denuded of cover for at least ninety days. Dr. Harler in a lecture in London in September, 1937 had emphasized the importance of protecting soil against harmful sun effects, but he was afraid his warning had not been sufficiently appreciated. In Ceylon it was common to find pruning and lopping of shade carried out at the same time. He thought it would be better to protect the soil by avoiding simultaneous lopping. He knew of cases where infertile soil had been rendered fertile by protection from the sun.

Sir John Russell asked how the land was protected and Mr. Wilkins replied by green manures, leguminous creepers, shrubs and by thatching with any available grass.

Sir John Russell, commenting on the very interesting observation, remarked that he would be glad later to have more information on the subject. The facts about sun effect were rather obscure. There was very little experimental work except Prescott's in Egypt and there exposure was found to be entirely beneficial, but the circumstances were quite different from those in Ceylon. In Egypt there was a certain amount of salt deposited in the soil and Prescott showed that the effect of the sun was to open up the soil in such a way as to allow the salt to be washed out. There was also a partial sterilisation effect which increased the available plant food. On the other hand, in the Sudan the work on sun exposure showed that sun destroyed nitrates in the soil and nitrates were the most readily available of plant foods. In the Fenland in England farmers declared that a summer bare fallow was bad treatment of the soil and reduced its productiveness. The difficulty of getting a decisive answer arose from the fact that when soil was covered it was very likely enriched. For instance a cover of growing green manure was obviously an advantage to soil fertility. To get a definite answer some way of shading soil without attendant fertility effects would have to be used in comparison with bare land.

Mr. P. A. Keiller said that he had read an account of laboratory experiments that claimed to show a definite loss of nitrogen from a block of soil with no vegetative covering, exposed to ultra violet rays. The author made a strong point of the loss of nitrogen from tropical soils owing to sun exposure. In reply to a question, Mr. Keiller said the book was Corbett's "Biological Processes in Tropical Soils."

Sir John Russell in reply said that opposed to this was the work of Dhar in India who maintained that exposure to sun could increase the nitrogen in a soil. The experiments in the Sudan that he had quoted were very carefully carried out, but work of this nature was very difficult to do and when he had visited the Sudan he had found that, notwithstanding the care devoted to them, these investigations were capable of being criticised. This question of the effect of sunlight would be worth taking up in well devised experiments. One thought at first sight that a clean cut answer ought to be obtained, but so far a really critical experiment was wanting. The Tea Research Institute would be a suitable place if the staff had time.

THE EFFECTS OF CULTIVATION AND WEEDS ON TEA

T. EDEN, D.Sc., A.I.C.

Four years ago at the Fourth Conference of this Institute Dr. Gadd and I dealt with the effect of drought on the growth of tea. Our inspections of droughty areas before the conference and the discussion that ensued showed that there was a striking concensus of opinion that 'high cultivation' had been no help in droughty areas but rather the reverse. Forking, weeds, green manures and mulching operations were all discussed at the time, but by way of explanation there was a peck of speculation for every pound of uncontrovertible fact. As a result of that very stimulating discussion and of my visit later in the year to Assam where cultivation practices are quite different and equally provocative, the Institute set out an experiment to explore the effects of cultivation and weeds. That experiment completes its first 3-year pruning cycle in April, and, as subsequent discussion may turn very largely, I suspect, on what we did or did not do there, and perhaps on what we ought to have done, I shall briefly describe the scope of that experiment.

Every plot was either clean weeded or selectively weeded (*i.e.*, all grasses and hard stalked species removed). Each plot had either a single forking of both rows on the occasion of annual manuring, or had three forkings of both rows annually. The two extra cultivations on those plots so treated were given at 3-month intervals so that the three times of cultivation were June, September and December; the June forking being common to all plots. I shall refer to these two treatments as normal and intensive cultivation. In addition each plot had either a single or a double dose of a standard manurial mixture. Combining these variations of treatment in as many ways as possible we are provided with eight different treatments. Those plots where weeds were allowed to grow and where normal cultivation was carried out had their weeds slashed at ground level on those occasions when their intensively cultivated counterparts were undergoing that treatment.

SOIL CONDITIONS

Any discussion of the problem that is engaging our attention this morning must take account of the soil, the plant's root system and its cropping growth, and I propose to deal with our experimental

investigation of these points as briefly as I can. Those who are interested in learning the details of the technique used will have an opportunity tomorrow during the demonstration that is scheduled in the conference programme. I am giving only the bare bones of the matter here. First of all we have procured an efficient implement for measuring the degree of compactness of the soil, obviously a matter of prime importance in estimating the gross physical results of cultivation and the duration of any effects produced. This instrument, the Culpin soil probe, forces a thin steel probe into the soil, and at the same time draws on a revolving chart a trace which shows the depth of penetration and the force (measured by the extension of a coiled spring) that is necessary to push the probe home. Figure I gives three examples of the traces obtained in this way: it should be unnecessary to say that the curves depicted are averages of a large number of replications.

The dotted curve represents the state of the soil 160 days after cultivation during which interval 55 inches of rain fell on a total of 106 days. The average intensity worked out at a quarter-of-an-inch per hour of actual rainfall. The general form of the curve shows that soil resistance is negligible until about the tenth inch, after which it rises steeply to become relatively stable at 14 inches. The points of interest are two (1) that on these plots, which were very carefully forked indeed, the full effect of cultivation is felt only to a depth of about 9 inches, (2) that five months after cultivation these plots, which were carefully isolated by a fence, showed little or no capping or caking of the surface For simplicity's sake I have not complicated the diagram with the corresponding trace made immediately after cultivation, but I shall ask you to take my word for it that the two traces are identical, within the limits of accuracy of the method, in this region. The direct comparison will be on view tomorrow.

By way of contrast, the continuous thin line shows a trace from a normal field three months after cultivation. The depth of forking is not so great but the main feature of the curve is the peak in the first inch or inch-and-a-half. This is indicative of a pronounced 'cap' on the soil formed as a result of the constant treading of the soil under any and every type of weather condition. The conclusion is that heavy beating rain does not by itself quickly destroy our surface tilth, a conclusion which it appears from other considerations may be a characteristic of certain tropical soils, and is at variance with similar findings on temperate soils. But the constant treading under adverse soil moisture conditions that would scandalize any English farmer, does denature the surface soil forming a relatively impervious barrier to the percolation of rainfall. It is evident that

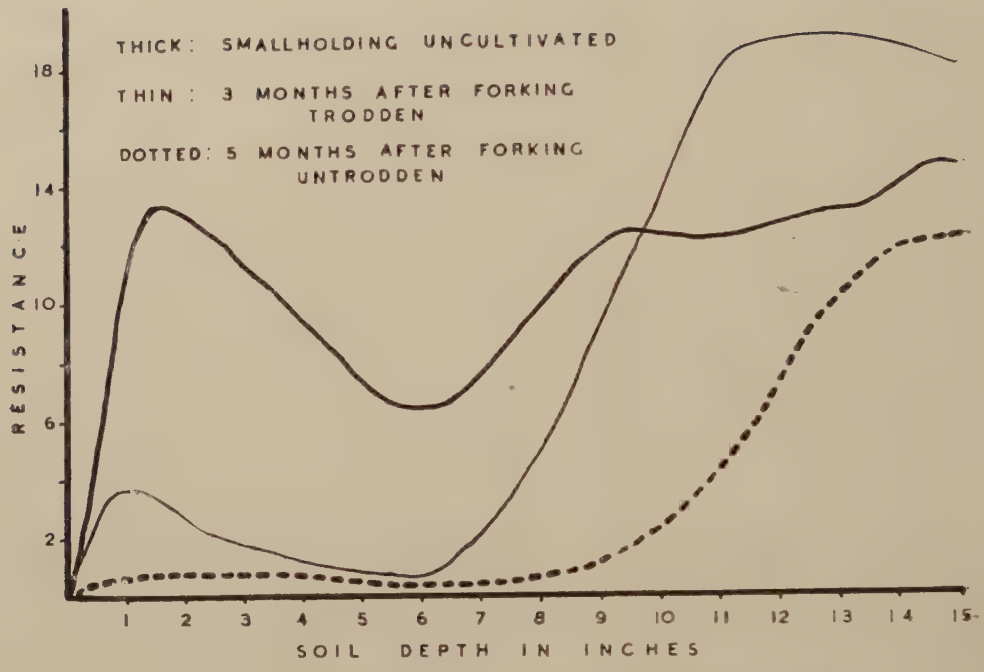

FIG. 1 SOIL DENSITY DISTRIBUTION

TOTAL ROOTS: RELATIVE WEIGHTS

FIG. 2 ROOT DENSITY DISTRIBUTION

though at four or six inches depth the cultivation effects have deteriorated but little, the percolation of rainfall is determined by the initial two inches, and hence run-off and soil erosion are encouraged. The remaining curve gives the picture from an uncultivated small-holding showing to an exaggerated degree the features to which attention has been called. In the case of the soils depicted by the continuous lines we have information about root distribution and this will be referred to in due course.

ROOT DISTRIBUTION

The question of how roots are affected by cultivation has been answered by taking a large number of sample blocks of soil from which the feeding rootlets were washed out, dried and weighed. You will see the process in action at St. Coombs tomorrow, and I shall be prepared then to give my reasons for adopting this method of root investigation since time does not permit of such a digression here. The blocks of soil were of course carefully standardised in size and each one had a volume of $8 \times 8 \times 3$ cubic inches, the latter figure representing the depth in the soil. Such a block was a sub-sample from one location and at each point eight such sub-samples were taken, depth by depth, till the total penetration was 24 inches. The first intention of this work was to determine to what extent cultivation influenced root distribution. The lower diagrams in figure 2 express the weight of roots found in each layer as a percentage of the total roots found down to two feet. In all three cases the distribution is similar irrespective of the degree of cultivation attained: the 'young' tea and the small-holding samples were taken from the sites from which the soil resistance data were compiled. The large differences in soil density are not reflected in large differences in distribution of root density. Assuming an average depth of twelve inches for the range of direct cultivation effects, we find that the percentage of roots in the first twelve inches is 74 for the young tea, 68 for old and 67 for small-holdings. We have washed out over 1,000 samples in order to get these data, but there is still a chance that this virtual equivalence in distribution may be a coincidence. At any rate we can say that so far cultivation, as normally practised, is not an over-riding factor in determining root distribution. That cultural treatments of all kinds affect the gross quantity of roots is evident from the upper diagrams representing the total quantity of roots found per sample

In conditions of drought, small differences in distribution of roots at lower levels may assume an importance not evident at other and more normal times. If we imagine the first fifteen inches of all these soils to have been depleted of such moisture as plants can make use of, *i.e.*, if we assume that the root system above the 15-inch

level is out of action, then the differences in the proportion of the whole root system that remain in action to maintain the growth of the bush assume some interest in the three cases. The smallholding would then appear to have an advantage over, for example, young tea. Whereas the former has 22 per cent of its root system in action, the latter has only 16. This aspect must be followed up before the general proposition that uncultivated tea will have an advantage over cultivated in effective root distribution in dry weather, can be seriously maintained. We shall concentrate on the attempt to confirm or confute this preliminary evidence.

CULTIVATION AND WEEDING EXPERIMENT

CROP RESULTS

PER CENT INCREASE OR DECREASE FOR VARIOUS TREATMENTS.

		Mean
(a). *Decrease due to intensive cultivation.*		5.3
(b). *Decrease due to weeds.*		
With intensive cultivation	8.7	7.4
With normal cultivation	6.1	
(c). *Increase due to manure.*		
With intensive cultivation	11.4	13.9
With normal cultivation	16.4	
(d). *Increase due to manure.*		
With clean weeding	12.8	13.9
With selective weeding	15.0	

We come now to the cropping capacity of the bush itself under different systems of cultivation. If no radical changes are effected in root distribution can over-cultivation diminish root efficiency and quantity to an extent capable of reducing yield? The figures in the accompanying table show a diminution in crop as a result of intensive cultivation of just over five per cent, and the trustworthiness of this decrease is assured. It is probable but not certain that this decline is connected with a restriction in the actual amount of roots produced under these conditions. There is a definite drop in yield owing to the competition of weeds and that drop is experienced whether the weeds are left on the ground without disturbance for a year, or whether they are checked by forking at the aforementioned

intervals. I am not prepared to vouch for the apparent slightly increased loss when intensive forking is combined with the selective weeding. Manuring has produced a distinct effect, and the point to which I wish particularly to draw attention is that the benefit of the extra manure has been felt by the selectively weeded plots to an extent at least as great as by the clean weeded plots. I put it this way advisedly because the two per cent difference tabulated cannot be spoken of with confidence.

FUTURE CULTIVATION METHODS

Such in compact form are the results obtained from this investigation. They are, as it were, individual pieces in a rather complicated jig-saw puzzle and in the rest of the time allotted to me I am going to try and describe in imagination what the whole picture may well look like when all, or at any rate more, of the pieces are in place. Other people may build a rather different construction in their mind's eye. If so, I hope they will contribute their views and experience to the discussion.

The picture I should draw of cultivation in tea, shall we say in another ten, twenty or it may be fifty years, is as follows: Cultivation will not be abandoned; there will be no attempt to grow tea on a 'forestry' principle, but there will be a greater realisation that the main function of cultivation is to ensure that water percolates through the soil, and that the porous or 'crumb' structure that allows of this depends more on the *kind* of cultivation than on its frequency. Where nowadays energy is spent on forking *after* the establishment of the tea, in the future, some of that energy, and the money spent on securing it, will be diverted to the initial preparations. In temperate farming great care is spent on preparing a 'seed bed.' Here I think we should prepare with equal care a 'root bed.' If we cannot forcibly alter root distribution by cultivation, let us at least alter root volume. Planting, or replanting will be on contours, strict or modified, and planting will be done in trenches not in holes. Cultivation will be reduced to the number of occasions on which something necessary to secure adequate growth or adequate soil structure can be economically supplied. This means no plain forking. But from the point of view of soil erosion the soil cap must be destroyed. I do not envisage a return to shallow forking, because that is not an efficient way of incorporating artificial or green manures, but I foresee an attempt by means of mulch and ground cover to protect the structure of those vital few inches. Unless some miracle in the form of a ground cover with no attendant disadvantages is discovered, that ground cover will be weeds.

And I hear you say — What about the inevitable loss of crop? In less than twenty years' time I hope it will be realised that the best way of saving soil capital and at the same time maintaining crop — on a long view — will be to compensate for that loss by means of adjusted manurial supplies, until that adjustment becomes unnecessary. If clean weeding is abandoned, it is possible, perhaps even probable, that a drop such as we have demonstrated here, may occur. But what the advocates of clean weeding have yet to consider is whether the last state of that clean land is not worse than the first. The indications from our experiment are that the loss of crop from weeds is not getting bigger. Because it occurs in a year or so it is forced upon our attention. It is the men that succeed us that are going to notice the loss due to soil erosion.

CONFLICTING VIEWS OF SELECTIVE WEEDING

And that brings me to the question, on which views are so conflicting, of why some reports on selective weeding are favourable and some otherwise. Experiment has shown that under carefully controlled conditions both weeds and severe soil disturbance are detrimental. On an estate that has been carefully weeded by hand and is in a high state of production I should expect selective weeding to cause a decline at first. There is only one detrimental factor to consider, that is weeds. But on an estate where weeds have grown profusely and have been energetically attacked, I believe a different behaviour is probable. We know for example that *Drymaria cordata* can easily get the upper hand. It flowers profusely and in a short time; a monthly weeding round is not sufficient to prevent its spread. It has been scraped out and forked out, and the only result has been to push the ecological balance over onto the side of rapid advancement, for virtually all competitors are removed. At this stage, having concentrated on two adverse factors, weeds and root disturbance, the selective weeding programme is put into operation. A mixed flora results and root disturbance over and above the average ceases. One contrary factor is removed and so yields increase. I should like your comments on this. My experience is that under selective weeding good fields suffer, bad fields improve. The illustration I have given is of the two extreme cases and all sorts of intermediate gradations exist.

You may be surprised to find that cultivation is not an unmixed blessing, and equally surprised to find that in other systems of agriculture similar results are being obtained. The Rothamsted and Cambridge work on cultivation shows that there is a limit beyond which cultivation gives either no positive or even a negative effect. I have on another occasion dealt with the fundamental reasons for

cultivation. Let no one say that my contribution to this conference discounts the need for adequate cultivation. I must stress this, because in this country everything is exaggerated and one's pronouncements are made to appear either pure white or dead black On the evidence as it stands, annual forking over the whole acreage seems to be the norm from which to arrange the cultivation programme so as to make the best use of artificial manure, green manure and compost, or to preserve a mulch of leaf and ground cover for the better protection of the soil.

DISCUSSION

Mr. W. J. Rettie said that Sir John Russell had touched on an interesting question — that of time of distribution of manures and the availability of plant nutrients. The Tea Research Institute recently had come forward with a very definite pronouncement on the subject. There were, he said, others who were of a different opinion and if, in the face of differing opinion people were loth to abandon certain practices from which they had had good results, he was sure that the officers of the Institute would understand. He referred particularly to pruning mixtures. They had had experts in the past who had laid down the law about certain agricultural practices which when followed were found to be impracticable; for example only a year ago they had had one such case when people had been actuated by what he might call the compost urge. Had they followed that urge they might have found themselves very deeply involved. On the question of pruning mixtures he did not wish to give his own experience beyond saying that some of those present, himself included, had had under certain conditions excellent results other than crop results. The gentleman who had originated the idea was present and the speaker thought it would be of interest to all if that gentleman would give them his views.

Mr. P. A. Keiller said that he did not agree with the Institute's opinion on the subject of manuring at pruning time. Perhaps the difference of opinion lay in the fact that Dr. Eden's arguments were based on crop figures and his were not, which put the speaker at a disadvantage in such arguments because it was much easier to argue from figures than to speak definitely without them.

He regarded the action of manure as being profoundly modified according to whether the bush was being plucked or unplucked at the time of manuring. The act of plucking induced an abnormal development of leaf that gave them the crop for which cultivation was undertaken, but this leaf growth did not stand in the proportion

to wood that was ordinarily the case when the bush developed normally. The manure applied when tea was plucked was used in giving more crop, *i.e.*, in developing new shoots which the act of plucking brought into being. The proportionate development of wood to leaf did not take place unless plucking was stopped, because food material was diverted to leaf production. On the other hand manure that was applied when the bush was not being plucked did not merely stimulate wood growth but supplied food for the bush to grow normally. He thought that they would get the wood they wanted when development of wood and leaf took place in their proper proportion.

The only time that tea was not plucked was between pruning and tipping, and the manure applied at pruning would be expected to encourage the natural development of the bush with regard to both leaf and wood. That growth was difficult to measure and there he was at a disadvantage because he had to speak in terms of general health of the bush and not in terms of pounds per acre. Referring to personal experience he could assure them that he had improved a great deal of tea by manuring at pruning time, not as regards increase of crop in the first twelve months, but as regards a very definite improvement in wood and the inducement of healing, *i.e.*, the growth of callus tissue over pruning cuts, both old and new.

Mr. Keiller reminded the conference that conditions had changed in the past fifteen or twenty years. When he was endeavouring to demonstrate the benefit of manuring at pruning time, much of the tea was in pretty poor condition and that fact would be remembered by those who knew Ceylon tea during the war period and before it. At the end of the war the tea was suffering from four successive years without manure and showed much wood decay in the pruned branches which had already been in evidence as far back as, say, 1910 or 1912. That tea had greatly improved and he had seen a progressive improvement since 1920-22 when pruning applications were first taken up. The symptoms were perhaps not so striking now, and those who had not had long experience of our tea might conclude that there never had been any need for a pruning mixture, but personally he was under no such delusion. Some people said that good tea did not require manuring at pruning time but that poor tea did. If that were so, it seemed not unreasonable to expect that good tea would become poor tea again if the pruning time treatment were withheld. His concern was not only with regard to crop but also with regard to wood-growth and general vigour, and he held very strongly that manuring only during plucking was manuring for crop. He was all for manuring for crop but not only for immediate crop, and he felt certain that they could safeguard their tea in other

ways by ensuring that the manure was taken up when the bush was not being plucked, *i.e.*, between the dates of pruning and tipping.

Dr. T. Eden in reply began by saying that it would be well to clarify the difference of opinion that existed between Mr. Keiller and himself. He had never suggested that a first year mixture should be discontinued. The crux of the argument was whether it was better to use that mixture at pruning time, or at a suitable date later. If one used the mixture at pruning time, some good would be done and Mr. Keiller was entitled to argue that he had seen the benefit from pruning mixtures. The speaker's position was that he considered the efficacy of the manure could be increased by delaying its application. He would start by asking why wood was desirable. He thought Mr. Keiller would agree with him that wood was wanted so that eventually crop should result from it. If it were possible to rear a strain of tea giving twice as much wood for the same amount of crop, he thought Mr. Keiller would confirm his own view that such a strain would be of no particular advantage (Mr. Keiller concurred). Mr. Keiller's argument was based on the correlation between wood produced and crop produced. The Tea Research Institute's experiments established two things: First that there was a very close relationship between the two types of growth under consideration: what Mr. Keiller had inferred as a matter of observation they had confirmed as a matter of direct experiment. But the argument cut both ways, if wood was followed by crop, then wood must precede crop unless in the meantime the system of management of the bush was altered. In the second place experiment had shown that at tipping time there was no difference between the weights of whole tippings from plots that had received a pruning mixture and those which had not at that time received any manure at all. He maintained quite definitely that tippings were an adequate criterion of wood production during the period under review. Whatever effect Mr. Keiller was ascribing to the pruning mixture, he (Dr. Eden) could say with equal certainty that it did not show up at tipping time. Thereafter they were both on common ground because manure used subsequently would increase both wood and crop.

At the time of speaking they were 21 months from the last pruning, and those plots that received their manure six months after pruning were 75 lb. per acre ahead of the pruning mixture plots. He was entitled to ask Mr. Keiller how long they were to wait for the result of this delayed action of increased production of wood of which Mr. Keiller made a point. There was a limit to the period during which this delayed action could be effective because at the end of the cycle they pruned away the wood and experimental experience showed that in so doing they brought back the cropping level

to about that of the previous first year period Though other factors in management might alter the proportion of wood to crop he maintained that such alteration could not be made solely as a question of manurial practice. He was not prepared to accept Mr. Keiller's premise that the ratio of wood to leaf was greater in the initial period than subsequently, but that was a matter of opinion. What was not a matter of opinion was the 75 lb. extra crop secured to date. On these and on general botanical and physiological grounds he felt that it was wrong to dissociate, as Mr. Keiller had done, the questions of crop and wood production.

Mr. H. J. Temple asked if they might have Dr. Gadd's opinion on the relative effect of a pruning mixture on wood and leaf growth.

Dr. C. H. Gadd said that the problem which had been discussed by Mr. Keiller and Dr. Eden was one which allowed of a botanical explanation. There was a very definite relationship between the radial growth of a stem, *i.e.*, its increase in diameter, and the extension growth of the leafy shoots. Increase in diameter of the stem was what has been termed wood growth while the terminal growth with leaf development was what in tea formed crop. To explain this relationship between wood growth and crop he likened the tea bush to a town, the houses of which were represented by the leaves. In such houses are many taps if the termination of each small vein may be regarded as a tap. When an ordinary suburban house is being built the plumber gets busy, lays the pipes within the house and when all is ready makes a connection with the nearest water main. When a tea bush house is built a connection with an existing water main is never made. Instead a new pipeline is laid down *via* the stem and the roots right back to the water reservoir which is the soil around the root tips. There is not merely one pipeline per house but one pipeline per tap, and the development of the pipelines must progress with the building of the house as water is required for the building. The pipelines referred to are wood vessels and the laying down of more vessels results in increase in girth of the stem. There was thus such intimate connection between leaf formation and wood growth that it was impossible to have one without the other.

Referring to Mr. Temple's question, Dr. Gadd said that the growth of root stem and leaf was so intimately connected that it was practically impossible to stimulate one without stimulating the others at the same time. As a stimulant at pruning time he thought that a pruning mixture could have little value as the presence of a larger amount of food material in the soil would not cause the buds to break any earlier. More important were climatic conditions. To illustrate his point Dr. Gadd referred to deciduous trees in England.

During the winter they were leafless and normally the buds burst in spring. A spell of warm weather in late winter often caused the buds to burst prematurely and that new growth was often killed by a late frost. Those conditions applied equally well to trees in the tropics. The bursting of buds after pruning depended upon such climatic factors as temperature and rainfall as well as upon the state of development of the buds themselves, and there was no apparent reason why the provision of a pruning mixture would speed up the breaking of the bud and the accompanying development of wood in stems and roots by so much as a day.

Mr. S. F. H. Perera referred to the subject of wind erosion. In Ceylon this type of erosion never received any consideration. In certain parts of the world where dry farming is customary they heard about wind erosion more than erosion by water and were told that fertile land was turned into desert. He wished to know what steps the Institute had taken to combat wind erosion in Ceylon wherever it occurred, and also what steps had been taken in other countries to combat wind erosion.

Dr T. Eden replied that the types of soil found in Ceylon were not so liable to wind erosion as those of other countries of which he had no personal knowledge. In Ceylon there was a type of dry erosion due to the disintegration of the soil mass on drying but that was independent of wind. He knew of no situation in tea where wind erosion occurred. The question of conditions in other countries he referred to Sir John Russell.

Sir John Russell said that typical wind erosion occurred when the land lay in great areas of rolling plains subject to hot dry winds and no rainfall for many months of the year. Under those conditions the practice had been to go in for strip farming growing a cereal crop of either wheat or maize in strips alternating with uncultivated areas. In the next year the strips were reversed in the hope of this keeping the soil anchored and capable of retaining the moisture of that year and carrying it on till the next so as to get two years' rainfall on one crop. That condition was not likely to arise in Ceylon since it was associated with big continental areas. They in Ceylon might congratulate themselves on not having that particular difficulty.

Mr. L. B. Green referred to Mr. Wilkins' remarks about the harmful effect of sunscorch on tea that had no shade. This was naturally greatest in times of drought. But in similar drought conditions, if there were thick shade, there would also be heavy loss of moisture, not through sunscorch, but by transpiration through the leaves of broad leaved shade species, such as dadaps. He had personally noted the bad effect of drought on tea in a well-shaded

area, and thought it was largely due to loss of soil moisture through transpiration of the leaves of the cover. He wondered which was worse, that or the sunscorch?

He would also like to know of a simple test for determining whether the carbon-nitrogen ratio of finished compost was correct, so as to avoid having to send samples to the Institute.

Dr. T. Eden said he thought the circumstances under which sunscorch and excessive transpiration reacted unfavourably on tea were quite diverse. In young clearings the soil got heated up if no shade was present and it was possible for small stones and gravel to become so intensely hot as to scorch the stem of a young plant causing it to ring and die back. That happened to many supply plants. But the transpiration problem was one of mature areas. Even if the plant's own mechanism did not sufficiently stop down moisture losses, they could at a moment's notice reduce the loss by lopping. On the other hand they could not produce shade to order, so he always preferred to risk an excess of shade to any degree of sunscorch. Regarding compost, if the strands of the material from which compost was made were not evident, or if on pulling a lump of compost apart the remaining strands offered no resistance, *i.e.*, if the structural tissues had been destroyed, then they might infer that the carbon-nitrogen ratio had been adequately adjusted.

Mr. J. D. Farquharson said he appreciated the emphasis laid on selection in weeding and would like to know broadly how to classify weeds for selection, so as to tell the sheep from the goats.

Dr. T. Eden said that in the first place it was advisable to get rid of all grasses. They were such avid users of nitrogen that they might cause temporary nitrogen starvation for the associated crop. Regarding the other weeds it was hard to get a labour force to remove only grasses and hard stalked non-spreading species that were of little use in holding up soil, but the best plan was first of all to allow everything that would develop (except grasses) to do so. He would not say to individuals, encourage such and such species, because circumstances altered cases. But having succeeded in establishing a cover it would be found that a few, perhaps three or four, weeds predominated, species capable of spreading and standing up to competition. The labour force could be taught the identity of these few and then allowed to take everything else out. In a short time these remaining species would colonise the whole area and there would be little difficulty in keeping a reasonably complete cover.

Mr. A. N. Paine asked whether the distribution of roots and branches closely corresponded and whether in that case there was a likelihood of ill-balanced growth on one side of a bush if manuring

was carried out in one row only owing to roots in that row taking up an undue proportion of the manure.

Dr. T. Eden replied that the answer to the question involved a reference to a demonstration that Dr. Tubbs had carried out in his department. Different lateral roots from the same bush had been immersed in dyes of different colour and the progress and destination of these dyes had been watched. This disclosed the fact that in the main the stream of food materials went in large proportion to localised branches. This was not entirely the case and a mechanism did exist for maintaining interconnection. This was also true for the manufactured foodstuffs produced by the co-operation of roots and leaves. He did not therefore think that there was any permanent damage to be expected from alternate row manuring.

Mr. C. H. Wilkinson asked leave to confirm Dr. Eden's description of the manner of colonisation in selective weeding. From ten years' records he had found that three or four useful species formed a perfect ground cover.

Mr. T. Glen Dickson asked whether selective weeding would increase cost of weeding, and if so, to what extent.

Dr. T. Eden replied that he could not answer the question as put because different circumstances would call for different answers. He thought the question of costing a system of selective weeding was strictly a job for the Superintendent who would then have to make his decision. The Institute could give Superintendents the agricultural facts. It could not give costing figures applicable to all circumstances.

Mr. I. L. Cameron said that Dr. Eden had indicated that cultivation, and by that he understood forking, could be overdone. Dr. Eden had given one cultivation per annum as the norm and the questioner wished to know whether one alternate row or one forking in both rows was intended. Since shade trees and bush green manures would need more frequent lopping than once annually, would he advise leaving these as a mulch on the ground?

Dr. T. Eden said in the experiment both lines were forked at one time. The depreciation in crop of 5 per cent due to increasing forking from once to thrice was so small that he did not think one double row forking as compared with one single row forking would show any appreciable difference. He would fork in green stuff whenever the time coincided with a normal forking programme and at other times mulch the green manure.

Mr. C. H. Wilkinson explained that in relation to Mr. T. Glen Dickson's question he could say that the cost of control of green cover and selective weeding in his trial was no more then than it was ten years ago.

Mr. Gordon Pyper said that his figures over a period of ten years had never exceeded Rs. 1.75 per acre per month.

Mr. R. A. Paterson said that if the soil was denuded of all cover, in his experience, in dry windy weather, wind erosion did actually take place.

Mr. C. de Lemos asked whether he was correct in assuming that at pruning time all feeding roots died back if all the leaves were taken off the bush. At the Nuwara Eliya elevation it took about six months for new leaves and feeding roots to form and he thought, on the assumption made regarding roots, most of the potential benefit from a pruning mixture would be lost.

Dr T. Eden said that their root sampling observations had not proceeded far enough to give an answer. On the question of whether roots actually died or became dormant at pruning time he would leave Dr. Tubbs to say since he had made sundry observations on that point.

Dr. F. R. Tubbs said that the experiments referred to had dealt with water uptake of pruned plants. Young plants removed from the ground with the greatest care and with roots immersed in water had shown a large decrease in water uptake as an immediate reaction to pruning, which suggested that on a mature bush after pruning the roots were at least reduced to a much lower state of activity.

Mr. J. C. Mitchell wanted to know whether the efficacy of pruning mixtures would be increased if they were not forked in at time of pruning. He wondered whether deep forking at pruning, by disturbing the root system, lessened the usefulness of the mixture and whether application two months prior to pruning would have a more beneficial effect.

Dr. T. Eden expressed his opinion that a pre-pruning mixture was no solution to the problem. His examination of records showed that pre-pruning mixtures had to make themselves felt before pruning either in crop or in some slight adjustment of food reserves. Once pruning had occurred no further benefit from the manuring seemed to occur. Experiments at Passara bore that out. He did not think that root disturbance at pruning would account for the lack of effect of manures used at pruning time which, as he had stated, gave no effective response at high elevations for 4 to $4\frac{1}{2}$ months after application.

THE IMPROVEMENT OF PLANTING MATERIAL

F. R. TUBBS, Ph. D., D. I. C., A. R. C. S.

The subject of this paper is a novel one for a Tea Conference in Ceylon, though a certain amount has already been said upon the subject in lectures at District Planters' Association Meetings. It was inevitable that the improvement of the races of tea available for planting would one day take up a large proportion of the energies of the Physiology Department. Though in Ceylon attention to this subject has been long overdue, the experience gained from experimental and advisory work on more pressing problems during the first six years of the Department's history will, I believe, result in the selection work in progress here and elsewhere in the Island being based upon a surer foundation than if the subject had been taken up in 1930 to the exclusion of the more pressing problems affecting existing tea bushes. Nevertheless, it is daily becoming more apparent that substantial and immediate effort is required if measurable progress is to be made in producing economic results within the next decade or so.

What practical results are to be expected? In brief, selection work holds the possibilities of giving races or clones of tea bushes that will provide larger crops of better quality tea at reduced production costs owing to easier plucking, pruning, etc. This sounds Utopian perhaps, but we have this certainty — that, whatever the practical difficulties, the intelligent application of selection methods to such a heterogeneous and uncritically accepted mass of bushes as we have in Ceylon today cannot fail to work improvement. It is sometimes argued that because such and such a jât produced a very large yield in one field of one estate, tea of such capabilities needs no selection for use under other and less favourable environmental conditions. Such an argument leaves out all account of quality and of the fact that selection aims at the production of higher yield as the result of improving the intrinsic vigour and yielding capacity of the plants, thereby avoiding the expense of achieving this result by raising the fertility level by manuring.

In considering the subject the first point of interest is the material available on which selection can be carried out. The available range

has been augmented by small importations of seed from other countries and in particular recently of Indian tea jâts under special license for research. While my views upon the lack of uniformity and the haphazard planting of seed-bearers in Ceylon are now well known, even if not altogether accepted by those responsible, from the point of view of making radical improvements by strict selection the amazingly heterogeneous nature of the collections of bushes we style "tea" fields has certain advantages. In short, it means that we have existing in our fields the progeny resulting from the admixture of the major types of tea bush, "China type," so-called "Manipuri" type and, probably to a much lesser extent, the large light leaved "Assam" type. These types I refer to are really rough divisions of the total range of variation and must not be regarded as botanical races when used in the sense usually used in planting circles. The Ceylon mixture is probably mainly of "Manipuri × China" origin, with greater or less amounts of China influence according to the age of the tea.

As might well be expected when the natural variation in characters of a botanical race is complicated and increased by groups of characters that have evolved in other races more or less geographically separated, there is no lack of variations in visible type. The leaf, of course, is the character most commonly given attention, and I would here like to stress that its size is often given an undue importance in assessing so-called "jât." While large and small leaved types of tea do undoubtedly occur, the comparison of leaf size must be made between leaves from trees of the same total age, age from pruning, cultural treatment, and growing in similar positions on the trees. When this is done, the size of the leaf can be a useful character, but when uncritically used it leads to such loose remarks as "the jât has improved since the field was pruned" or "since the field received extra manure." It is far better to confine one's self to observed facts — namely that the size of the leaf has increased. In fact the utmost caution is necessary to distinguish between local and temporary environmental effects on the one hand, and characters which are due to the inherited constitution of the particular plant under consideration on the other.

In general, tea in low-country areas is of more uniform type and often of higher jât than older tea up-country. This is due at least in part to the fact that many low-country bearers were grown from seed imported from India after some progress had been made in that country towards the production of more uniform bearers. Nevertheless, the forcing conditions of growth at low elevations tend to mask differences which are really present and so one comes across interesting cases of jâts considered uniform at low elevations which

are not so uniform up-country. I have observed this personally in the case of Indian jâts which greatly impressed me by their relative uniformity under plains conditions in Assam. The same jâts here, as far as seedling observations go, appear to exhibit a greater range of variation.

Since we cannot expect the desired uniformity of vigour or of composition in a visibly heterogeneous race, there is an obvious basis for the present policy, which I am glad to say is gaining numerous adherents, of eye selection of existing bearers for vigour and uniformity. But it must be plainly understood that this is but a temporary palliative to tide over the inevitably lengthy period before improved bearers become productive and displace older unimproved types from the market. There seems to be a prevalent idea, which I would like to express an opinion on in passing, that special sanctity attaches to seed from old bearers. Provided that the seed from young bearers is well filled and of adequate size, (*i.e.*, a low number of seed to the pound) there is no justification for specially preferring that from old bearers. I personally would have no hesitation at all in using graded seed of the first year's crop of young *selected* bearers in preference to graded seed from old *unselected* or less carefully selected bearers. There is no reason, in my opinion, why the steadily increasing band of those who are carefully selecting individual trees for use as seed-bearers should not profit from their by no means negligible labours the first year seed is available from the new bearers.

No one will seriously deny that our bushes are very heterogeneous in appearance but we are interested in appearance only in so far as it indicates uniformity in yield and composition of the crop and the possibility of standardisation of cultural operations.

The yield and vigour of individual plants certainly do vary considerably. For example, the highest yield recorded on St. Coombs has been 0.73 lb. dry matter in 21 weeks, equivalent to, say, 5,000 lb. per acre per annum though of course such calculations have to be used cautiously. Lest this be though unusual, I may say that to my chagrin these values have been several times exceeded in selection work on commercial tea estates who have already undertaken this work! Again, high yields have been reported from clones in Java, in which country clones raised from selected mother trees are already in plucking and even in production as seed-bearers.

As regards the chemical composition of the crop in relation to the individual variations between bushes, investigations have not progressed far enough for it to be justifiable to do more than allude

to the Russian work showing variations in the tannin content of flush from different bushes and to the Java and North Indian conclusions that the characters of the teas made from different bushes vary considerably. I may, however, give an example of the indications that are being obtained at St. Coombs as a result of the use of the method of individual bush manufacture worked out by Mr. Lamb. The data are based on four comparable manufactures on each bush and must be regarded as preliminary in nature.

Bush A has given consistently a very coloury tea, normally of very common character, with bad infusions.

Bush B has given coloury liquors, of fair to poor quality, and greener infusions than the others.

Bush C has given liquors of useful colour, of fair to relatively very good quality, with relatively good infusions.

Bush D has given teas of fair colour, quality being fair to good, and infusions fair.

To quote from the report of Mr. Horne, to whom we are very greatly indebted in this connection, "Amplifying this report, the difference in the liquors of these samples is really extraordinary." "Discounting the abnormal conditions of manufacture which seem to give the liquors a peculiar bitter, strong character, the range of quality is from poor common low grown tea to quality that, as far as I could judge from these samples, would under normal conditions be considerably better than any teas at present being produced outside Nuwara Eliya."

It may be noted that the good tea referred to was made from shoots of tipping character produced after the rested bush had been pruned back. The tree in question has the additional interest that it is apparently a high yielder, and has a good habit of growth. It thus appears that it is possible that high yield and high quality may on occasion be found in the same bush.

This leads us to face up to the facts that every bush is *not* the equal of every other bush in economic value, and that a distinct possibility exists of bushes of greatly improved value being found in the future as the result of careful search among the existing bushes on your estates. I hope that in considering these points later, the uselessness of expecting to obtain substantial quality improvement by merely "thinning out a 'nice' area of tea and running the remaining bushes up as seed-bearers" will not be lost sight of. Real improvement involves prolonged work — I do not wish to disguise the fact. But those who are undertaking it cannot fail to be rewarded in some, though varying, degree.

For those sufficiently interested to undertake the work involved, a memorandum on selection is available on application to the Institute, and I hope that all those interested will attend the demonstration of selection for yield that will be given at St. Coombs tomorrow. It is sufficient to state now that a method of selection for yield which is as trouble-free and involves as little labour as possible has been devised. You will find the details in the sheets you have already received. (See Appendix).

The question of quality cannot be handled on estates at present. But if estates are willing to make-over material sufficient to plant up one of our series of clonal plots at St. Coombs, subject to the Institute's later opinion that the clone is worthy of such test, experimental manufactures will be carried out. But of course, if the clone proves of no great value as a yielder, this cannot be guaranteed, for what we want is yield and quality combined.

You will notice that I have been alluding to clones of tea. These, as you know, consist of plants propagated vegetatively and not by seed and are therefore series of replicas of the respective mother trees. To be able to increase the numbers of a given tree without the segregation of characters inseparable from reproduction by seed in such a heterogeneous crop as tea, is obviously of the greatest importance both for practical purposes and for the extent to which it facilitates the adequate testing or "proving" of selected trees. During the last two years a considerable amount of experience of different methods of vegetative propagation has been obtained, and it is now possible to propagate any selected bush with sufficient ease to allow both of the stricter examination of its yield and quality, and also of its multiplication for use as a component of a seed-bearer area consisting of several selected clones. For reasons which I do not propose to go into now, the formation of seed-bearer areas by the use of only one clone is not considered advisable in the present state of our knowledge. These methods of vegetative propagation, which are described in the other sheet circulated in connection with this lecture, can be seen tomorrow at St. Coombs. They have not yet been used for the planting of large areas of one clone, and the economic possibilities of the method have yet to be investigated in this direction.

As far as we can go at present the position may be summed up as follows: Satisfactory indications have been obtained that improvements in both yield and the quality of the produce may be obtained by the stringent selection of individual bushes from among our existing tea. While propagation by budding or by cuttings with a view to obtaining large areas of tea of one clone is still a matter for the future, working on the basis that on the average

like tends to beget like, it is recommended that carefully selected bushes be propagated to form new multi-clonal tested seed-bearer areas to replace the existing bearers in the Island. This policy must, from its nature, take very many years to fructify, but I consider that since supplying with improved material is obviously desirable, quite apart from any question of replanting, there is every reason that we should delay no longer in starting the work.

Those who visit us on the last Wednesday of any month can see the whole selection process, whose details I have deliberately not detained you with today. The Institute's personnel is insufficient to permit officers to visit individually the large numbers of estates that are applying for information but it does arrange to demonstrate all the essentials of the methods in routine use at St. Coombs to those who care to come and see them.

The Industry cannot hope to approach perfection in a year; almost certainly not for many years, for it is dealing with very difficult and abstruse problems in tackling selection work, but the Institute will do what it can to speed the process to the best of its ability, for it is only by the active co-operation of commercial interests and research that relatively speedy results may be obtained. But in so difficult a subject, I would ask you to remember those words of Hillaire Belloc:—

> "Our brains are trained, our books are big,
> But still we always fail
> To answer why the Guinea-pig
> Is born without a tail!"

DISCUSSION

Mr. Helling asked whether rootsuckers of convenient size could be taken from fields at the time of pruning and used as supplies with advantage.

Dr. Tubbs said that while there was no objection to doing so he felt that the same percentage of success would not be achieved with rootsuckers as would be achieved with stumps. Rootsuckers needed to be lifted carefully with the bulk of their roots intact and could not be treated with the same severity as stumps. He did not feel that the process would be worth while unless the bushes from which the rootsuckers were removed had been selected for vigour, or other desirable characters.

Mr. Helling said that he had not actually had experience of the practice but felt that vigorous rootsuckers might be expected to make good supplies. He had observed that bushes affected with

Phloem necrosis frequently bore rootsuckers which had not been affected by the disease. He wished to know whether any experiments had been carried out on the subject.

Dr. Tubbs said that he did not expect a rootsucker to form a potentially better bush than its mother tree, so that rootsuckers should only be taken from selected bushes. With regard to *Phloem necrosis* he suggested that there was a possibility of the disease being present in the rootsuckers but not yet exhibiting visible symptoms. Experiments had been carried out on layering and it had been found that layered branches had to be transplanted with considerable care if a good percentage of success were to be obtained. Layered branches could be regarded as similar to rootsuckers in this respect. An experiment was in progress which was designed to stimulate the production of large numbers of rootsuckers by the removal of the aerial portions of the bush. The results from this were not yet available.

The Chairman requested that reference to *Phloem necrosis* be postponed until Dr. Gadd had given his paper.

Mr. D. S. Cameron asked whether any experiments had been carried out to determine whether different jâts varied in their resistance to Shot-hole borer.

Dr. Tubbs said that a considerable amount of visual observation of low-country tea had convinced him that there was very little hope indeed that any existing jât would be found appreciably more resistant to Shot-hole borer than normal. The only hope of progress in this direction that he could hold out was that a few individual bushes might be discovered which were resistant to Shot-hole borer. This possibility had engaged his attention throughout his selection work and would not be lost sight of, but so far no bushes of this character had been discovered. If such a bush was found it would immediately receive active attention, as resistance to Shot-hole borer would undoubtedly be a very valuable character.

Mr. Keiller asked whether good tap root development could be expected from rooted cuttings.

Dr. Tubbs stated that with regard to tea there has not been sufficient time to gather information on this point, but young plants grown from cuttings were growing as well as young plants raised from seed so that it could be assumed that the respective root systems were equally efficient. Work on other crops had been influenced to some extent by the prejudice of cultivators against the use of cuttings arising from the fear that the plants would exhibit inadequate root development in the lower soil layers. As far as he

knew further experience with all these crops had shown such a fear to be unfounded. In his experience the tap root did not go very deep in many Ceylon tea areas and he felt that there was some confusion of thought on the subject, since the rôle of the tap root could be taken over by any vigorous lateral or root which descended down to the level of the sub-soil. He personally considered that there was no reason to expect plants grown from cuttings to be less satisfactory in growth than those grown from seedlings.

Mr. J. Byde Martin asked if any estimate could be given of the time required to select a clone for yield and later for quality.

Dr. Tubbs stated that a test for quality could not be carried out on clonal material supplied to St. Coombs until sufficient time had elapsed to allow the plants from the cuttings to come into production. He tentatively suggested 6 years from the rooting of the cuttings, but felt that this problem might possibly be later dealt with by budding on to established bushes. It was, however, too early to make any definite remarks on the subject.

Mr. A. R. T. Gibbon asked whether dark leaf or light leaf bushes should be chosen when selecting desirable bushes for growth as seed-bearers.

Dr. Tubbs said that since selection depended on the characters of individual bushes it was impossible to expect that there would be a consistent difference between dark and light leaf types and referred the questioner to an answer on this subject made in his lecture to the Dimbula Planters' Association earlier in the year which was reported in *The Tea Quarterly*. In India there appeared to be a prejudice in favour of light leaf types for manufacturing purposes. He had no experience of real light leaf jâts in Ceylon as he knew of no genuine light leaf areas in Ceylon. Most of the lighter jâts appeared to have been mixed with a dark leaf strain, in some cases possibly of China origin. In Java it appeared that some light leaf types were more susceptible to adverse environmental conditions than dark leaf types, but others were as hardy as the latter. He felt that for selection purposes one should be guided entirely by the vigour of the individual bush.

Mr. Groves asked how long it would take before selected bushes would produce seed suitable for growth for test of the character of the progeny. He asked that because he had seed bearers on his estate which were cut down as an experiment in 1932. In 1938 he found that the seed from these bearers gave a germination of only 65 per cent as against 95 per cent in the case of seed from unpruned bearers.

Dr. Tubbs said that he was inclined to think that there was some other factor at work than the pruning of the seed-bearers, since large areas of seed-bearers had been pruned down and regrown in all tea-producing countries without detriment to the character of the seed. He asked what the reason was for cutting them down.

Mr. Groves said that they were cut down during the depression with a view to bringing them into plucking.

Dr. Tubbs said that it was impossible to give a definite opinion without a more detailed knowledge of the bushes, but he did not consider that the pruning seven years ago was the real reason for poor germination. Well filled seed from plucking bushes pruned every 3 years germinated quite well. In practical work on estates this was forcibly brought to one's notice when tea was uprooted for replanting purposes, a vigorous growth of young seedlings frequently being found a few months later. For this reason he felt that some other factor than pruning was at work in the case mentioned by Mr. Groves. He would be willing to use well filled seed as soon as seed was produced for the purpose of testing progeny character.

Mr. G. K. Newton asked whether the growth of bushes as seed-bearers which had been selected for high yield from amongst the bushes in a plucking field might not result in low yields of seed.

Dr. Tubbs said that he was glad Mr. Newton had raised that question as it was one which required clarification. They were only interested in seed-bearers for the character of their progeny and he envisaged the possibility of high-yielding bushes of very desirable character for growth in plucking fields being found in some cases to be very shy fruiters. If such was the case it would be necessary to increase their areas of seed-bearers to give the desired quantity of seed. The fact that a desirable clone gave low yields of seed when grown as seed-bearers could not be regarded as a serious disadvantage of the clone. He did not consider the prior history of pruning and plucking would influence the later fruiting character of selected bushes.

Mr. E. J. K. Garthwaite asked whether Dr. Tubbs had found that small leaf jâts rooted better than large leaf jâts.

Dr. Tubbs stated that he was unable to give any general ruling in answer to the question, as he had found that bushes varied in their rooting capacity independently of their leaf characters.

Mr. C. W. Newton said that he had always believed that the tap root was of considerable importance to the bush, but Dr. Tubbs had appeared to throw doubt on this. He asked what roots were of advantage to the bush if the tap root was of no advantage.

Dr. Tubbs stated that he had not suggested that the tap root was of no advantage to the bush but had expressed his opinion that in the conditions affecting tea in plucking in Ceylon any lateral root which penetrated to an equal depth would compensate for the absence of the genuine tap root. Examination of uprooted bushes showed that in many cases it was difficult to determine whether the tap root was of more importance to the bush than vigorous adjacent lateral roots, while cases were frequently found where injury to the tap root had resulted in its functions being taken over by the lateral roots. That this was of very frequent occurrence indeed could be estimated from the fact that tea stumps made satisfactory bushes. In planting good size stumps the fine tip of the tap root was almost invariably broken or cut off before planting. Any roots which subsequently grew downwards would therefore be lateral roots. He considered that this demonstrated that genuine tap roots, *i.e.*, the developed primary seedling root, were not essential in any way to the growth of satisfactory bushes.

Mr. I. L. Cameron asked to what extent the vegetative progeny of high-yielding bushes could be expected to exhibit the same high-yielding characters as the mother trees.

Dr. Tubbs said that in selection work it was always necessary to "prove" selected mother trees by vegetative propagation and further test. Experience in rubber had, he believed, shown that carefully selected mother trees were usually all found to be above the average in the yield of the vegetative progeny and that of such carefully selected mother trees a very few would be of exceptionally good character. He believed that the same would be found to be the case in tea. He did not wish to disguise the fact that disappointments were more frequent than successes when one was looking for clones of exceptional value but there was no doubt in his mind that strict primary selection would achieve a definite improvement in the average value of the progeny.

Mr. Gordon Pyper asked whether Dr. Tubbs would recommend the planting as supplies of self-sown seedlings collected from among tea in plucking.

Dr. Tubbs replied that he would not use such plants for ordinary supplying as it was better to select bushes of good character from which to obtain the seed rather than to continue the custom of planting any seedling which grew. He said that he felt very strongly that such self-sown seedlings should not, however, be discarded as they provided a very valuable source of plants for use in tea hedges as an anti-erosion method for the purely nominal cost of collecting them from the field.

APPENDIX

SELECTION FOR HIGH YIELDS

The basis of the method consists in locating those bushes possessing yield and vigour much above the average in spite of conditions of soil and of competition from surrounding bushes being normal as far as is known. This, when strictly applied, includes no bush situated on spoil earth or drain or roadsides and no bush having young bushes or vacancies in anyway adjacent to it — thus with normal planting only bushes having eight normally sized bushes adjacent to it are considered. Thus:—

X X X
X O X
X X X

These bushes may be picked out at any stage during the cycle.

(1). When field is in plucking.—Abnormally good bushes situated as above are picked out by eye, labelled and submitted to yield recording by the method described later. The assistance of intelligent pluckers is a considerable help in picking these out. Needless to say bushes possessing characters not considered desirable are not included no matter what their vigour.

(2). When field is due for pruning.—This is the method now in routine use on St. Coombs, owing to the ease with which the first preliminary choice of bushes is made. The pruners are instructed to leave about 5 per cent of the biggest bushes in the day's work unpruned, avoiding roadside and drainside bushes, and bushes with vacancies or young plants adjacent.

After the prunings have been lined the unpruned bushes may be inspected with relative ease and any bushes wrongly chosen by the pruners are pruned down. This work may be carried out by a conductor or kangany, so avoiding unnecessary work for the Superintendent. From the bushes that remain the best bushes up to the number it is intended to examine by yield records are marked by numbered labels costing in the neighbourhood of 10 to 15 cents a piece. If there is no immediate hurry the labelled bushes may be pruned and brought into plucking normally, and this is probably the best method for ordinary estate use. Recording is then started after the third tipping. If it is desired to speed up the process bushes may be cut across 9 inches above the old clean pruning cuts. It is very important to see that this height is maintained all over

the bush as pruners unused to this work are liable to prune bushes in such a way that the bushes are pruned with varying degrees of severity. At this elevation the cut-across bushes are plucked to one foliage leaf above the cut-across level six weeks after pruning. This is much easier than what would be normally considered practical on a tea estate at the elevation of 4,500 feet. During the first three rounds the "plucking" consists in removing *everything* above one leaf, even buds. This is to produce early production of laterals. After these three rounds are completed another 3 rounds of normal plucking are given and yield recording then commences.

Yield Recording.—The bushes are plucked weekly, a normal standard of plucking being maintained. In order to reduce the amount of weighing to a minimum, the following procedure is recommended: drill bags with tapes attached (procurable from the Wellawatte Spinning and Weaving Mills at 18-20 cents a piece) are numbered to correspond with the label numbers. At the commencement of the plucking of a group of fairly closely adjacent bushes, bags belonging to that group are laid on the surface of the bushes and the correspondence of bag numbers and label numbers checked. The flush is then inserted into the bag which is re-tied and despatched as convenient to the factory where drying is carried out.

Subject to the approval of the Insurance Co. concerned, it is recommended that the bags be laid out on the banks of tats next to the bulking chamber, where they should remain until the next plucking. After eight pluckings are done the bags are more thoroughly dried off in the middle of the ensuing week by placing on the trays of a stationary dryer. After drying the dry leaf is weighed in a tin of known weight on a postal balance weighing in eighths of an ounce. (The weight of the tin need not be subtracted for each record provided the same tin is always used).

The 25 per cent lowest yielders have their labels removed and are discarded from the selection experiment. After a further 8 pluckings a quarter of those that remain are discarded and so on until only those yielding at a rate equivalent to three times the yield of the field remain. These are then subjected to careful bush-to-bush comparison and the required number of the best and most suitable selected either for propagation and further tests or for direct use as "unproved" selected bearers.

Methods for further test and "proving" are based upon vegetative propagation and the actual design of the experiments and comparison of the results should be done in consultation with the Institute. The testing of high yielders for quality and character of teas produced can at present only be provided for at the Institute under conditions which will be referred to.

PROPAGATION OF TEA BY SINGLE INTERNODE CUTTINGS IN PEATMOSS

The type of cutting employed consists of a leaf and the stem beneath it down to a point a little above the junction of the next leaf below with the stem. If a suitable stem is cut just above each leaf with a *sharp* knife such cuttings are readily obtained. The cut should not be very oblique. Very young leaves are undesirable as they wilt and rot; old leaves tend to drop off either during propagation or too early after planting out in the field. The maintenance of an adequate leaf surface is of importance and it is therefore very desirable to pay attention to this point. Fully mature leaves on green or *lightly* reddened stems are the best, and it is no disadvantage if the bud on the axil of the leaf has started to grow a little. If much growth has been produced, however, the tender shoot should be pinched back to the first fish leaf from the stem before planting.

The peatmoss (medium grade) is lightly beaten up to break up lumps and moistened for several days prior to pressing in the cuttings, so that it is thoroughly wet but not sodden. About six inches is a suitable depth in a box or bed; if in a box the cuttings may be covered with advantage by a sheet of glass. In any case arrangements should be made to prevent direct sunlight or even bright light reaching the cuttings. It is for this reason that the back of an airy verandah or similar structure is suitable. With rather less satisfactory results, cuttings may be rooted under shades of hessian or manna grass supported on wire netting instead of in boxes or beds under more sheltered conditions. The cuttings should be lightly moistened down every evening, or more frequently in very dry weather, *but the peatmoss must not be rendered sodden.*

The best time of the year in the South-West Zone is before the break of the South-West Monsoon. By its end the cuttings will have developed young roots and may be gradually hardened off prior to planting in the North-East Monsoon. Five to six months should be allowed for rooting and hardening off, when the plants can be lifted with a ball of peatmoss attached and planted either in baskets or bamboo pots, in a nursery for the production of stumps, or direct into a prepared plot. If the latter step is taken, the services of an experienced garden cooly are necessary in the early stages of establishment to prevent sunscorch, etc., as unless care is taken considerable loss may occur from this cause. The use of a heavy shade of cut grevillea foliage thinned daily after the first fortnight obviates this.

Once established, cuttings appear to grow equally as well as seedlings of the same age, but different clones exhibit very marked differences in ease and speed of rooting. These differences reach their full expression when sand is used as a rooting medium, but are less obvious, though still marked, when peatmoss is used.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

RULES FOR THE OCCUPATION OF ST. COOMBS GUEST HOUSE

(1). The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.

(2). Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed. Two double rooms are available for the use of visitors accompanied by their wives.

(3). All visitors must sign the Visitors' Book on arrival.

(4). A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priority in the allocation of accommodation when on official business.

(5). Complaints or suggestions shall be entered in the book provided for the purpose and not made to the Guest House Staff.

(6). All payments due for services rendered shall be made in *cash* to the steward-in-charge and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The steward is forbidden to give credit or to accept cheques.

(7). Liquor is supplied for consumption *in the premises only*.

(8). The Institute accepts no responsibility for cash, jewellery or other valuables of any kind left in the Guest House.

(9). All breakages will be charged for at cost price.

ROLAND V. NORRIS,

Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon :—

(1) Mr. R. G. Coombe

(2) Mr. James Forbes, (Chairman).

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association :—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron

(6) Mr. J. C. Kelly

(C) Representing the Low-Country Products' Association :—

(7) Mr. S. F. H. Perera

(D) Representing the Small-Holders :—

(8) Mr. T. B. Panabokke

(E) Ex-Officio Members :—

(9) The Hon. the Financial Secretary.

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

CONTENTS.

		Page
1.	Editorial	1
2.	Proceedings of the Sixth Conference of the Tea Research Institute held on the 13th and 14th February, 1939. (Part I):—	
	(a). Address by the Chairman of the Board, Mr. James Forbes	3
	(b). The Work of the Institute by Roland V. Norris, D.Sc., F.I.C.	5
	(c). Soil Management by Sir E. John Russell, D.Sc., F.R.S.	16
	(d). The Effects of Cultivation and Weeds on Tea by T. Eden, D.Sc., A.I.C. ...	24
	(e). The Improvement of Planting Material by F. R. Tubbs, Ph.D., D.I.C., A.R.C.S.	38
3.	Notices	51

The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with the *Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.